LAWRENCE BERKELEY LABORATORY - UNIVERSITY OF CALIFORNIA

ENGINEERING NOTE

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PROGRAM - PROJECT - JOB

MAG

ALS – STORAGE RING
VACUUM ASSEMBLY / INSTALLATION

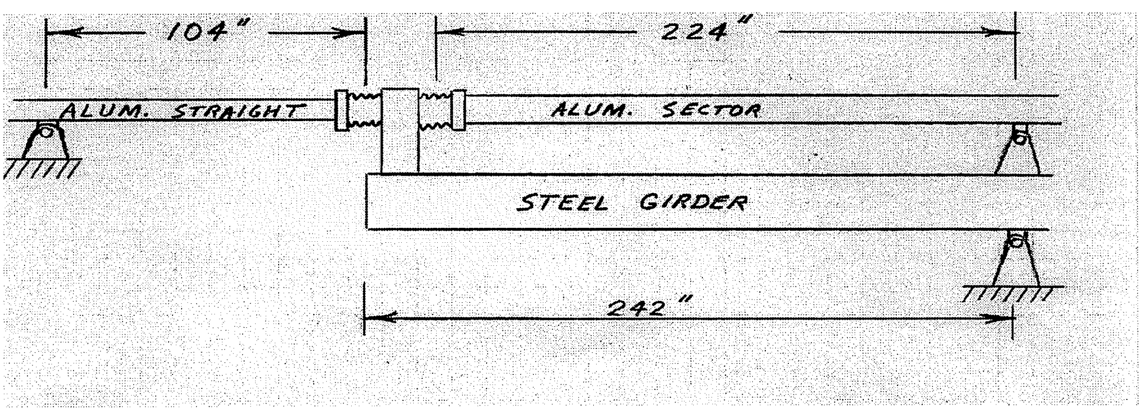
TITLE

RF FLEX BANDS – COLD TEMPERATURE LIMIT

This note addresses a concern about possible damage to the storage ring flex bands when the building heating is turned off during a winter shutdown. The idea is that if the storage ring became cold enough, the aluminum vacuum chambers would contract until the flex band's coil springs bottomed out, tearing the flex band ribbons.

Some guidance on this can be found in Tom Henderson's 1992 LSME Note 506, but he was interested in the flex band operating temperature range (keeping the fingerstock in contact) which he found to be 17C to 29C. A sketch of the flexband design from Tom's note is shown on page 3.

An examination of our flex band model shows that there is at least 0.100" travel before the flex band tensioning springs become coil bound. The question then is, what air temperature would result in contraction of the vacuum chamber lengths to produce a 0.100" elongation of the flex bands? A worst-case geometry is shown in the following sketch. The ALS insertion device straight aluminum vacuum chambers are axially constrained to the concrete floor near their midpoints. The curved sector vacuum chambers are axially constrained to their steel girders near their midpoints, and the girders in turn are axially constrained to the concrete floor near their midpoints. The relevant dimensions are as shown in the sketch, with flexbands C and D located within the two bellows.



Coefficients of thermal expansion: Aluminum: 22×10^{-6} in./in./C, Steel: 12×10^{-6} in./in./C

Flex band C elongation:

Δx = straight contraction + girder contraction
$\Delta x = (104" \times 22 \times 10^{-6} \times \Delta T) + (242" \times 12 \times 10^{-6} \times \Delta T)$
$\Delta x = 5.19 \times 10^{-3} \times \Delta T$
or,
$\Delta x = 0.0052"$ per degree C

Flex band D elongation:

Δx = sector contraction - girder contraction
$\Delta x = (224" \times 22 \times 10^{-6} \times \Delta T) - (242" \times 12 \times 10^{-6} \times \Delta T)$
$\Delta x = 2.02 \times 10^{-3} \times \Delta T$
or,
$\Delta x = 0.0020"$ per degree C

Therefore, flex band C is the worst case. If 0.100" of elongation range is available, then max. $\Delta T = .100/.0052 = 19.2C$, or 34.6F.

Assuming a 21C (70F) installation temperature, the cold limit is then 2C or 36 degrees F.

It seems very unlikely that the storage ring would get that cold with the heating off for a few days, though the limit should be kept in mind.

Postscript :

Ben Feinberg has posed a good question: What if the flexband finger stock has welded itself to its mating parts after carrying large currents in a clean atmosphere for a very long time? This is certainly conceivable, and this would seem to reduce the elongation travel available when the ring cooled down.

Dan Colomb has two comforting observations:
1. He has never seen any evidence of fingerstock welding in any of the flex band assemblies that have been removed from the ring. Apparently the dissimilar metals prevent this from happening.
2. If it did, he thinks that there is still enough flexibility in the individual fingerstock loops to allow them extend by distorting their shape without breaking the flexband ribbons. For a single cycle, they would probably return more or less to their original shape when the flexband length returned to normal, without significant damage.

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A sketch of the ALS flexband design, taken from Tom Henderson's LSME note 506 :